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**DEPARTMENT OF CHEMICAL ENGINEERING**
**COLLEGE OF SCIENCE AND TECHNOLOGY**
**COVENANT UNIVERSITY, CANAANLAND, OTA**

# 2010-2011 ALPHA SEMESTER EXAMINATION

**COURSE:** CHEMICAL PROCESS ANALYSIS [CHE 310]
**EXAMINER:** Prof. S.S. Adefila, Adewale A. Adeosun
**INSTRUCTION:** Answer all questions. **Time: 2.5 hours**

**Gas Constant, R = 8314 J/kgmol-K , 1 atm= 101325Pa. Van der Waals parameters, in S.I. units, are:**

$$a = \left(\frac{27}{64}\right)\frac{R^2T_c^2}{P_c} \qquad b = \left(\frac{1}{8}\right)\frac{RT_c}{P_c}$$

**Antoine Equation parameters for pressure in mmHg and temperature in K.**

| | A | B | C |
|---|---|---|---|
| Ethyl Alcohol | 18.5242 | 3578.91 | - 50.50 |
| Water | 18.3036 | 3816.44 | - 46.13 |

1. **The density in kg/m$^3$ of an ideal gas that has a molecular weight of 0.123kg/kgmol at 27$^o$C and 1 bar is:**

   **A. 0.00202 B. 0.00547 C. 0.00183 D. 0.00493 3 MARKS**

**INSTRUCTION: Use Figure 1. to answer question 2 to 3**

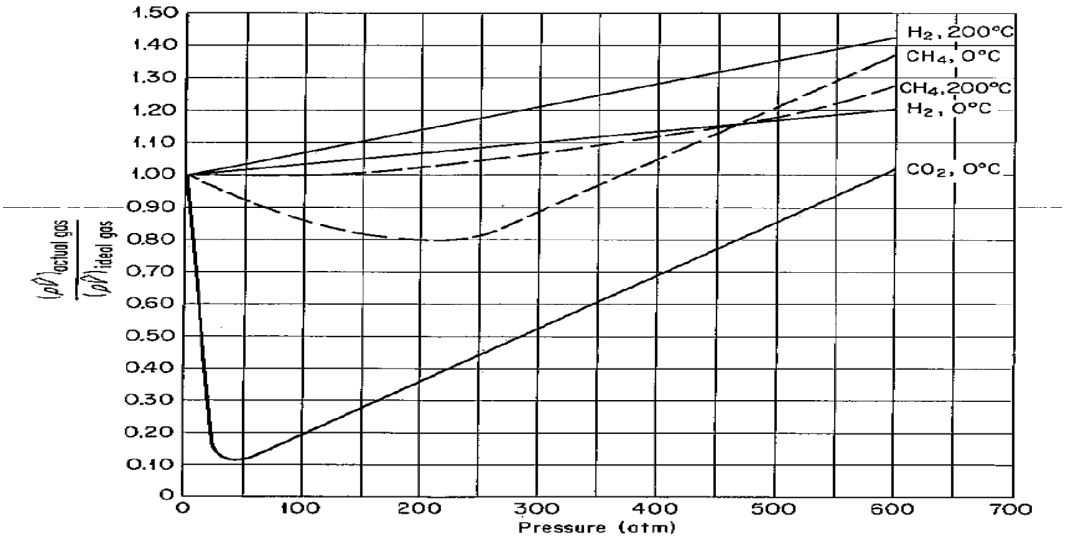


**Figure 1. Compressibility Chart**

2. **The real volume (in m$^3$) of 100kg of ideal hydrogen gas at 200$^o$C under 150 atm is:**

   **A. 1.423 B. 0.1423 C. 14.23 D. 0.01423 3 MARKS**

3. **Calculate the real volume (in m$^3$) of 50kgmol of methane at 273K at 200 atm:**

   **A. 7.48 B. 5.48 C. 4.48 D. 3.48 3 MARKS**

4. Given Van der Waal's Equation as $(P+ an^2/V^2) \times (V-nb) = nRT$, R= 8.314J/mol-K, $P_c$ =42.5bar and $T_c$= 96.6°C, calculate the temperature of 66g of propane in 5 $ft^3$ cylinder at 0.4 bar.

A. 456K B. 644K C. 922K D. 788K 4 MARKS

5. Calculate the saturated pressure of ethyl alcohol in (mmHg), using Antoine's equation, at 300K.

A. 4.2 B. 2.4 C. 66 D. 11 3 MARKS

6. The ethyl alcohol vapour mole percent in a binary mixture with air at 300K temperature and a total pressure of 165mmHg in a 75 mole percent ethyl alcohol liquid feed to a flash distillation still is:

A. 15 B. 30 C. 45 D. 45 3 MARKS

Propylene, an important monomer in packaging industry, has its thermodynamic properties represented in Figure 2. Assuming the gas stream exist under a pressure of 250 psia and specific entropy of 1.42, answer Questions 7 to 11.

7. The inlet temperature of the gas stream is:

A. 120 B. 140 C. 160 D. 180 2 MARKS

8. The inlet enthalpy of the gas stream is:

A. 515 B. 615 C. 715 D. 415 2 MARKS

9. If the inlet stream is expanded at constant enthalpy to a specific volume of 6.0, the specific entropy is:

A. 1.44 B. 1.46 C. 1.52 D.1.60 3 MARKS

10. The Degree of Saturation of the inlet stream is:

A. 30 B. 50 C. 60 D. 80 2 MARKS

11. If the inlet stream undergoes an isobaric change from inlet enthalpy to 420 BTU/Lb, what is the vapour quality of the resulting stream:

A. 0.5 B. 0.6 C. 0.7 D. 0.9 3 MARKS

Figure 3 is a heat engine working on the Carnot cycle principle. Answer Questions 12 to 14 using information provided.

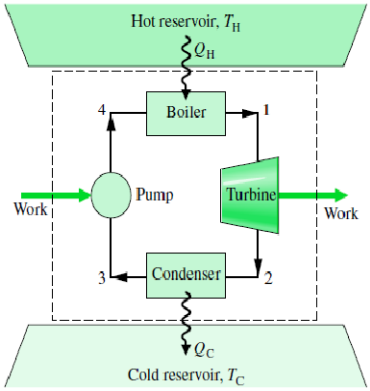


Figure 3. A Typical Heat Engine

12. Given that the hot reservoir temperature is 77°C and the cold reservoir is at 17°C and work at the pump is negligible, the efficiency of the engine is:

A. 0.78 B. 0.17 C. 0.87 D. 0.37 3 MARKS

13. **Assuming the work input at the pump is 125 kJ/kg with $Q_H$ and $Q_C$ being 450kJ/kg and 150 kJ/kg respectively, the work output in turbine is:**

**A. 475 B. 425 C. 175 D. 225 2 MARKS**

14. **Assuming no work input to the pump, with $Q_H$, $T_H$ and $T_C$ 450kJ/kg, 137$^o$C and 37$^o$C respectively, the cold reservoir heat is:**

**A. 340 B. 122 C. 430 D. 212 2 MARKS**

**Pick True (T) or False (F) for questions 15 to 16**

15. **At dew point, $\sum x_i = 0$** **2 MARKS**
16. **At bubble point, $\sum x_i = 1$** **2 MARKS**

**Suppose that a liquid mixture of 4% n-hexane and n-octane is vaporized and using the data given below:**

$$\ln(p^*) = A - \frac{B}{C+T}$$

where $p^*$ is in mm Hg and $T$ is in K:

| | A | B | C |
|---|---|---|---|
| n-hexane ($C_6$): | 15.8737 | 2697.55 | −48.784 |
| n-octane ($C_8$): | 15.9798 | 3127.60 | −63.633 |

17. **If the total pressure is 760mmHg, calculate the bubble point temperature:**

**A. 293 B. 493 C. 193 D. 393 4 MARKS**

18. **The saturated vapour pressure of n-octane in mmHg is:**

**A. 661 B. 561 C. 698 D. 654 3 MARKS**

19. **The n-octane vapour mole fraction is:**

**A. 0.536 B. 0.636 C. 0.726 D. 0.826 3 MARKS**

20. **Show that the equation below is true for flash vaporization:**

$$1 = \sum_{i=1}^{n} \frac{x_{F_i}}{1 - \frac{L}{F}\left(1 - \frac{1}{K_i}\right)}$$

**7 MARKS**

21. **A heat engine, using water as working fluid, operates between boiler and condenser temperatures of 280$^o$C and 120$^o$C, respectively. The temperature drop is:**

**A. 400 B. 160 C. 120 D. 280 1 MARKS**

22. **The efficiency of the heat engine is:**

**A. 0.71 B. 1.41 C. 0.41 D. 0.29 3 MARKS**

**INSTRUCTION: Use Figure 13.11 to answer Questions 23 to 25**

23. **Write the material balance equation around the absorber** **2 MARKS**
24. **Write the energy balance equation around the absorber.** **3 MARKS**
25. **The Generator-Absorber Unit serves the same purpose as a turbine. TRUE or FALSE** **2 MARKS**